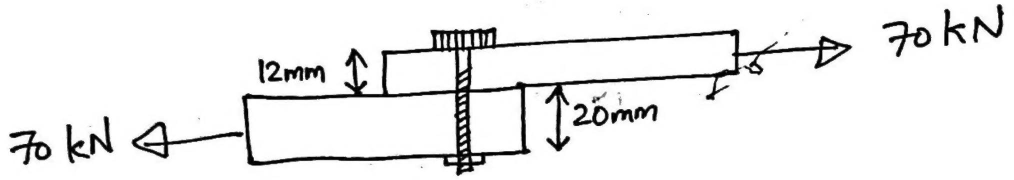
Q1) Design a ~~lap joint~~ bolted connection between 2 plates of thickness 12 mm & 20 mm each, subjected to a load 70 kN. Use M16 bolts of grade 4.6, and Fe 410 grade plates.

Ans:



Design of bolts:

(i) Design shear capacity of bolt

(Pg 75 – IS 800 cl. 10.3.3)

$$V_{dsb} = \frac{f_{ub}\,(n_n A_{nb} + n_s A_{sb})}{\sqrt{3}\ \gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$ ($\because$ 4.6 grade bolts)

$\gamma_{mb} = 1.25$ (Pg 30 – Table 5 of IS 800)

$n_n = 1$

$n_s = 0$

$A_{nb} = 0.78\ \pi/4 \times 16^2 = 157\ mm^2$

$A_{sb} = 0$

$$\Rightarrow V_{dsb} = \frac{400\,(1\times 157 + 0)}{\sqrt{3}\times 1.25} = 29006\ N$$

$= \underline{29.01\ kN}$

(ii) Design bearing capacity of bolt (Pg 75 – IS800 Cl. 10.3.4)

$$V_{dpb} = \frac{2.5 k_b \, d t f_u}{\gamma_{mb}}$$

where $d = 16$ mm

$t = 12$ mm (thinner plate)

$f_u = 410$ N/mm²

$$k_b = \text{smaller of} \begin{cases} e/3d_o = \frac{27}{3 \times 18} = 0.50 \\ p/3d_o - 0.25 = \frac{40}{3\times18} - 0.25 = 0.49 \\ f_{ub}/f_u = \frac{400}{410} = 0.98 \\ 1 \end{cases}$$

$= 0.49$

Assume $d_o = 16 + 2 = 18$ mm (Refer Table 19 – page 73 of IS800)

$e = 1.5\, d_o = 1.5 \times 18 = 27$ mm

(refer Pg 74 – Cl. 10.2.4.2 – machine cut)

$p = 2.5d = 2.5 \times 16 = 40$ mm

(refer Pg 73 – Cl. 10.2.2 – pitch)

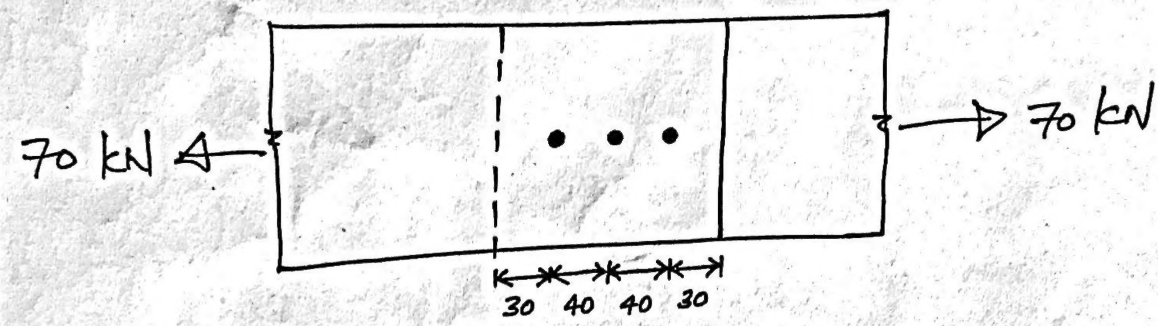
$$\Rightarrow V_{dpb} = \frac{2.5 \times 0.49 \times 16 \times 12 \times 410}{1.25}$$

$= 77146$ N $= \underline{77.15 \text{ kN}}$

∴ Bolt value = Smaller of bolt capacities

$= \underline{29.01 \text{ kN}}$

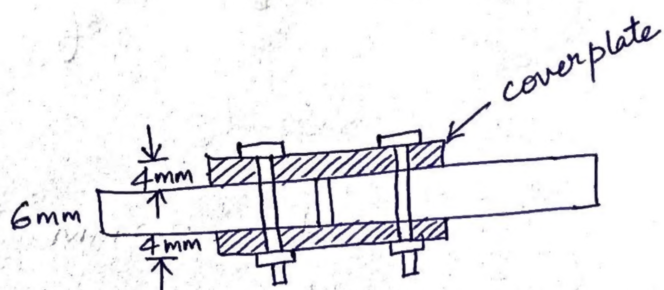
No: of bolts required $= \frac{70}{29.01} \approx \underline{3 \text{ nos}}$



Q2

Q. A ~~single bolted~~ double cover butt joint is used to connect two plates 6 mm thick. Assuming 4.6 grade M20 bolts and 4 mm thick cover plates. Plates are of grade fe410. Design the joint, if requires to transfer a force of 100 kN.

Ans:



Shear capacity of bolt

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \frac{(n_n A_{nb} + n_s A_{sb})}{\gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$ (for 4.6 grade bolts)

$\gamma_{mb} = 1.25$ (Table 5 – Pg 30)

$\left.\begin{array}{l} n_n = 1 \\ n_s = 1 \end{array}\right\}$ there are two shear planes each passing through thread & shank

$A_{nb} = 0.78\ \pi/4 \times 20^2 = 245\ mm^2$

$A_{sb} = \pi/4 \times 20^2 = 314\ mm^2$

$$\Rightarrow V_{dsb} = \frac{400}{\sqrt{3}} \frac{[(1 \times 314) + (1 \times 245)]}{1.25}$$

$= 103.28\ kN$

Bearing capacity of bolt

$$V_{dpb} = \frac{2.5\, k_b\, d\, t\, f_u}{\gamma_{mb}}$$

~~where k_b =~~

~~e =~~

$$\text{where } k_b = \text{smaller of} \begin{cases} e/3d_o \\ p/3d_o - 0.25 \\ f_{ub}/f_u \\ 1 \end{cases}$$

$d = 20$ mm

$d_o = 20 + 2 = 22$ mm (Pg 73 – Table 19)

$e = 1.5 d_o = 1.5 \times 22 = 33$ mm
(Pg 74 – Cl. 10.2.4.2)

$p = 2.5 d = 2.5 \times 20 = 50$ mm
(Pg 73 – Cl. 10.2.2)

$f_{ub} = 400\ N/mm^2$

$f_u = 410\ N/mm^2$

$$\Rightarrow k_b = \text{smaller of} \left\{ \begin{array}{ll} \frac{33}{3\times 22} & = 0.50 \\ \frac{50}{3\times 22} - 0.25 & = 0.51 \\ 400/410 & = 0.98 \\ 1 & \end{array} \right\} = 0.50$$

$$t = \text{smaller of} \left\{ \begin{array}{l} 6\text{ mm} \\ 4+4 = 8\text{ mm} \end{array} \right\} = 6\text{ mm}$$

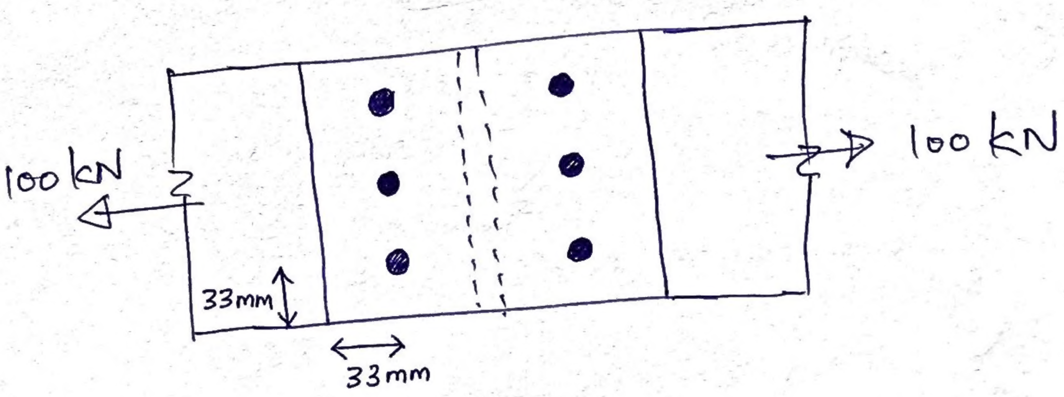
$$V_{dpb} = \frac{2.5 \times 0.5 \times 20 \times 6 \times 400}{1.25}$$ ← smaller of f_{ub} & f_u

$= \underline{\underline{48 \text{ kN}}}$

∴ Strength of bolt or Bolt value $=$ Smaller of $\begin{cases} V_{dsb} \\ V_{dpb} \end{cases}$

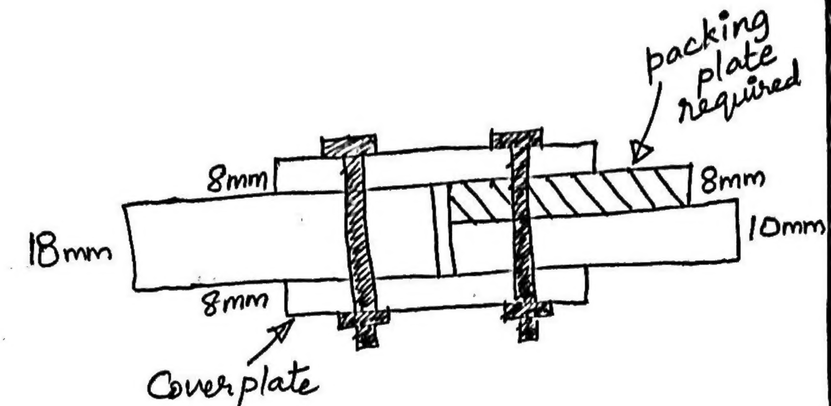
$= \underline{\underline{48 \text{ kN}}}$

∴ No: of bolts required on each side of the double-cover butt joint $= \frac{100}{48} \approx \underline{\underline{3 \text{ nos}}}$



Q: Determine the design shear capacity of bolt for a joint comprising 10mm & 18mm thick plates connected by two coverplates of 8mm thick. Use M20 bolts of 4.6 grade.

Ans:



Shear capacity of bolt

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \frac{(n_n A_{nb} + n_s A_{sb})}{\gamma_{mb}}$$

where $f_{ub} = 400\ N/mm^2$

$\gamma_{mb} = 1.25$

$\left.\begin{array}{l} n_n = 1 \\ n_s = 1 \end{array}\right\}$ two shearplanes, each passing through shank & thread

$A_{nb} = 0.78\ \pi/4 \times 20^2 = 245\ mm^2$

$A_{sb} = \pi/4 \times 20^2 = 314\ mm^2$

$$\Rightarrow V_{dsb} = \frac{400}{\sqrt{3}} \frac{[(1\times 245) + (1\times 314)]}{1.25}$$

$$= \underline{103.28\ kN}$$

Since a packing plate of thickness exceeding 6mm is used, reduction factor (β_{pk}) is required to be multiplied.

$$\therefore \beta_{pk} = 1 - 0.0125\, t_{pkg}$$

$$= 1 - (0.0125 \times 8)$$

$$= \underline{\underline{0.90}}$$

$\therefore$ Design shear capacity of bolt

$$= V_{dsb} \times \beta_{pk}$$

$$= 103.28 \times 0.90$$

$$= \underline{\underline{92.95\ kN}}$$